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Statistical Assesment of Ground Water Quality using Physico-Chemical Parameters in Bassi Tehsil of Jaipur District, Rajasthan, India

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Statistical Assesment of Ground Water Quality using Physico-Chemical Parameters in Bassi Tehsil of Jaipur District, Rajasthan, India

Umesh Saxena [α] & Swati Saxena [σ]

Abstract - Water is an essential natural resource for sustaining life and environment but over the last few decades the water quality has been deteriorated due to its over exploitation. Water quality is essential parameter to be studied when the overall focus is sustainable development keeping mankind at focal point. Groundwater is the major source of drinking water in rural as well as in urban areas and over 94% of the drinking water demand is met by groundwater. The study has been carried out to assess the ground water quality and its suitability for drinking purpose in most rural habitations of Bassi tehsil of Jaipur district, Rajasthan, India. For this purpose, 50 water samples being collected from hand pumps, open wells and bore wells of villages of study area were analysed for different physico-chemical parameters such as pH, electrical conductivity, total alkalinity, total hardness, calcium hardness, magnesium hardness, chloride, nitrate, fluoride and total dissolved solids.

pH value in the study area found from 6.3 to 8.7. EC ranges from 1100-16000 μmhos/cm and total alkalinity between 70 to 990 mg/L. Total hardness ranged from 30 to 980 mg/L and calcium hardness from 10 to 480 mg/L. Magnesium hardness varied from 20 to 500 mg/L and chloride from 20 to 3620 mg/L. Values of nitrate concentration varied from 9 to 224 mg/L and fluoride from 0.28 to 11.5 mg/L while value of TDS ranges from 770 to 11200 mg/L. The study reveals that almost all parameters were exceeding the permissible limits. As per the desirable and maximum permissible limit for fluoride and nitrate in drinking water, determined by WHO, BIS and ICMR standards, 64% and 42% of groundwater sources are unfit for drinking purposes respectively. Due to the higher fluoride level in drinking water, the several cases of dental and skeletal fluorosis have appeared at alarming rate in this region. After evaluating the data of this study, it is concluded that drinking water of Bassi tehsil is not potable and there is an instant need to take ameliorative steps in this region to prevent the population from adverse health effects.

Keywords : groundwater quality, physico-chemical parameters, statistical parameters, ph, electrical conductivity, total alkalinity, total hardness, calcium hardness, magnesium hardness, chloride, nitrate, fluoride and tds, bassi tehsil, and rajasthan.

I. Introduction

Water is life's matter and matrix, mother and medium. There is no life without water." In now a days, the modern civilization, urbanization and expanded population resulting with industrial operation has intensified the old problem of polluting our life, mother and medium. At present our life, mother and medium is being polluted and even worse situation is that we encounter with scarcity of this degraded quality of water too. It has raised certain basic challenges in our environment and we have been suffering both the problems of quality and quantity of water. In India groundwater is the major source of drinking water and over 94% of the drinking water demand is met by groundwater. Water quality is essential parameter to be studied when the overall focus is sustainable development keeping mankind at focal point, since it is directly linked with human welfare.

Statistical investigation offers more attractive options in environment science, though the results may deviate more from real situations (Nemade and Shrivastava, 1997). The correlation provides an excellent tool for the prediction of parametric values within a reasonable degree of accuracy (Venkatachalam and Jabenesan, 1998). The quality of water is described by its physical, chemical and microbial characteristics. But, if some correlations are possible among these parameters, then the more significant ones would be useful to indicate fairly the quality of water (Dhembare and Pondhe, 1997). A systematic study of correlation of the water quality parameters not only helps to assess the overall water quality but also to quantify relative concentration of various pollutants in water and provides necessary clue for implementation of rapid water quality management programmes (Dash et al, 2006).

Rajasthan is the largest state in the country in terms of geographic spread. It has an area of 342,239 lakh Sq kms being largest state of the country having 10.41 % of the country's area and 5.5% of nation's population but has low water resources i.e. 1% of the country's resources. The state has extreme climatic and geographical condition and it suffers both the problems of quantity and quality of water.

Review on the literature showed that no studies have been undertaken in the study area in regard to physico-chemical characteristics of water yet. So the objective of this study is to investigate the quality of drinking water (underground water) in most rural habitations of Bassi Tehsil of Jaipur, Rajasthan, India.

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II. Materials and Methods

a) Study Area

Jaipur district with geographical area of 11,151 sq. km forms the East-central part of Rajasthan (INDIA) which is administered by 13 tehsils and 13 blocks. The district covers about 3.3% of total area of the State. Jaipur, the capital city is also popularly known as Pink city and is situated towards central part of the district. The semi-arid district receives normal annual rainfall of 527mm (1901-71) while average annual rainfall for the last 30 years (1977-2006) is 565mm. Over 90% of total annual rainfall is received during monsoon. (CGWB, 2007; JDA, 2012)

Bassi Tehsil of Jaipur district is almost 29 KM far away from the main city having the area of 654.69 sq. km. It is located at $26^0$96' N latitude and $75^0$62'E longitude. In Bassi Tehsil there are 210 villages (famous for their leather footwear and Embroidery beading). There are no major surface water sources in the study area however, main sources of drinking water are open wells, hand pumps and bore wells.

b) Water Sampling

Ground water samples of a total of 50 villages in Bassi Tehsil of Jaipur district were collected in pre-cleaned and rinsed polythene bottles of two litres capacity with necessary precautions (Brown et al. 1974). The samples were collected, during April 2012 to March 2013 from manually operated hand pumps, open wells and bore wells.

c) Physico-chemical Analysis

All the samples were analyzed under the following Physico-chemical parameters; pH, Electrical Conductivity (EC), Total Alkalinity (TA), Total Hardness (TH), Calcium hardness (Ca H), Magnesium hardness (Mg H), Chloride, Nitrate, Fluoride and Total Dissolved Solid (TDS). The analysis of water samples were carried out in accordance to the standard analytical methods (APHA, 2005). All the chemicals used were of AR grade and double distilled water used for preparation of solutions. Details of the analysis methods are summarized in Table-1.

Table 1 : Parameters and methods employed in the physicochemical examination of water samples

S.No.	Parameters	Unit	Method Employed
1.	pH	-	Digital pH-meter
2.	Electrical Conductivity	μmhos/cm	Digital Conductivity-meter
3.	Total Alkalinity	mg/l	Titrimetric method (With HCl)
4.	Total Hardness (as $CaCO_3$)	mg/l	Titrimetric method (with EDTA)
5.	Calcium Hardness (as $CaCO_3$)	mg/l	Titrimetric method
6.	Magnesium Hardness (as $CaCO_3$)	mg/l	Titrimetric method
7.	Chloride (as Cl^-)	mg/l	Titrimetric method (With $AgNO_3$)
8.	Nitrate (as NO_3^-)	mg/l	Spectrophotometric method
9.	Fluoride (as F^-)	mg/l	Ion Selective Electrode
10.	Total Dissolved Solids	mg/l	Digital Conductivity-meter

d) Statistical Analysis

In the present study Minimum, Maximum, Average, Standard Deviation and Correlation coefficient (r) have been calculated for each pair of water quality parameters by using Excel spreadsheet for the experimental data.

The standard formulae were used in the calculation for statistical parameters are as follows (S.P. Gupta, 1999):

$$Mean\ (\mu) = \frac{\sum x}{N}$$

x = Value of Observation
N = Number of Observation

$$\text{Standard Deviation } (\sigma) = \sqrt{\frac{n\sum x^2 - (\sum x)^2}{n(n-1)}}$$

x = Values of Parameter
n = Number of Observations

$$\text{Karl Pearson's Coefficient of Correlation } r = \frac{n\sum xy - \sum x \sum y}{\sqrt{n\sum x^2 - (\sum x)^2}\sqrt{n\sum y^2 - (\sum y)^2}}$$

x, y = Values of array 1 and array 2 respectively.
n = Number of Observations

III. Result and Discussion

The respective values of all water quality parameters in the groundwater samples are illustrated in Table-2. All the results are compared with standard permissible limit recommended by the Bureau of Indian Standards (BIS), Indian Council of Medical Research (ICMR) and World Health Organization (WHO), depicted in Table-3. Statistical Parameters of groundwater samples of study area are summarized in Table-4.

a) pH

pH is measure of intensity of acidity or alkalinity of water. All chemical and biological reactions are

directly dependent upon the pH of water system (Rao, 2006). In our findings pH varied between 6.3-8.7. Maximum pH was recorded at S41 in village *Dhani Baba Ki* and minimum pH was recorded at S20 in village *Ateri*, which are not within the permissible limit prescribed by BIS, ICMR and WHO. The variation of pH in ground water samples of study area has been depicted in Figure – 1, which shows that most of the samples are alkaline in nature. The pH of water is very important indication of its quality and provides information in many types of geochemical equilibrium or solubility calculations (Mitharwal et al., 2009).

b) Electrical Conductivity

The electrical conductivity of water depends on the concentration of ions and its nutrient status. Based on electrical conductivity values, the water quality can be classified as poor, medium or good (Gulta, Sunita, & Saharan, 2009). In the present investigation maximum conductivity 16000 μmhos/cm was observed at S20 in village *Ateri* and minimum 1100 μmhos/cm at S30 in village *Todabhata.* The maximum limit of EC in drinking water has been prescribed as 1400 μmhos/cm (WHO: 2006), Samples are exceeding the permissible limit extremely as shown in Figure- 2.

Table 2 : Analysis of ground water quality parameters in villages of Bassi Tehsil (Jaipur, Rajasthan, India)

S.No.	Sampling Site	Cod	pH	EC	Alk. mg/l	TH mg/l	Ca H mg/l	Mg H mg/l	Cl^- mg/l	NO_3^- mg/l	F^- mg/l	TDS mg/l
1.	Kanota	S1	7.4	3100	650	100	70	30	280	20	1.78	2170
2.	Dyarampura	S2	8.5	4100	710	250	110	140	540	84	1.2	2870
3.	Bassi	S3	8.5	2100	560	120	40	80	150	109	1.8	1470
4.	Naya Bagrana	S4	8.4	3700	70	590	250	340	470	186	1.02	2590
5.	Moondli	S5	8.4	3400	990	90	30	60	290	10	3.89	2380
6.	Bishanpura	S6	8.0	3100	700	180	70	110	410	15	2.4	2170
7.	Roopura	S7	8.4	3300	80	770	370	400	60	27	11.5	2310
8.	Hardi	S8	8.2	3300	350	970	470	500	110	13	4.6	2310
9.	Ralawata	S9	8.2	3200	80	760	360	400	60	25	11.0	2240
10.	Hardhyanpura	S10	8.0	3200	350	980	480	500	110	11	4.4	2240
11.	Heerawala	S11	8.2	3200	340	960	460	500	100	10	4.2	2240
12.	Ramratanpura	S12	8.4	3300	280	980	480	500	120	10	4.1	2310
13.	Biharipura	S13	8.2	3300	880	100	40	60	300	16	4.0	2310
14.	Handi	S14	8.1	2743	780	150	60	90	210	75	10.0	1920
15.	Akhepura	S15	8.0	3500	520	220	100	120	460	76	0.69	2450
16.	Banskhoh	S16	7.7	1900	400	360	120	240	100	48	2.6	1330
17.	Peipura	S17	7.8	3300	260	950	450	500	400	12	1.7	2310
18.	Jhajhawad	S18	7.2	6000	640	280	130	150	1320	68	0.48	4200
19.	Sankh	S19	6.5	4500	380	870	410	460	720	142	1.1	3150
20.	Ateri	S20	6.3	16000	90	660	280	380	3620	146	0.36	11200
21.	Barala	S21	7.3	5200	480	120	40	80	720	206	4.3	3640
22.	Hanumanpura	S22	6.9	5100	160	80	30	50	880	224	2.1	3570
23.	Peepalabai	S23	7.3	4300	710	60	20	40	560	50	3.1	3010
24.	Basedi	S24	7.2	3000	160	180	80	100	480	48	1.6	2100
25.	Mandurupura	S25	7.7	2600	680	280	120	160	120	202	0.28	1820
26.	Ghasipura	S26	8.3	2300	760	70	30	40	50	26	11.4	1610
27.	Ramsinghpura	S27	8.3	2200	800	70	30	40	70	26	10.9	1540
28.	Baseri	S28	8.3	1600	540	70	30	40	60	9	6.4	1120
29.	Gangarampura	S29	8.2	2200	810	80	30	50	90	29	11.4	1540
30.	Todabhata	S30	7.1	1100	320	70	20	50	30	68	0.4	770
31.	Jagdishpura	S31	8.4	2000	140	50	20	30	50	33	6.2	1400
32.	Ramrakhpura	S32	8.1	1700	520	30	10	20	80	60	0.5	1190
33.	Nangalkarna	S33	8.0	2300	800	70	30	40	80	29	5.9	1610
34.	Danau Khurd	S34	7.2	1300	360	170	60	110	100	106	4.5	910
35.	Sewapura	S35	7.4	1700	560	40	20	20	30	24	0.54	1190
36.	Ramsar	S36	6.8	1700	470	90	30	60	180	68	0.58	1190
37.	Dubali	S37	8.0	1600	520	60	20	40	40	48	0.99	1120
38.	Virajpura	S38	7.6	1400	420	220	90	130	20	22	0.95	980
39.	Kishanpura	S39	8.0	1500	440	160	70	90	20	20	1.9	1050
40.	Tungi	S40	8.1	1200	440	60	20	40	20	12	0.59	840

41.	Dhani Baba ki	S41	8.7	3300	730	150	60	90	350	12	2.15	2310
42.	Bainada Mod	S42	8.5	2300	840	250	110	140	100	59	0.98	1610
43.	Danau Khurd	S43	8.2	2400	450	280	120	160	140	22	2.9	1680
44.	Anantpura	S44	8.3	2100	460	150	60	90	170	18	1.8	1470
45.	Ratanpura	S45	8.4	1500	480	90	30	60	70	24	1.5	1050
46.	Kaneta	S46	8.4	1700	560	70	30	40	40	14	0.7	1190
47.	Nimora	S47	8.2	2700	520	50	20	30	80	11	3.2	1890
48.	Kesopura	S48	8.2	2200	810	50	20	30	80	25	5.8	1540
49.	Kawarpura	S49	7.4	1943	110	210	90	120	340	86	1.1	1360
50.	Madhogarh	S50	8.0	1500	470	80	30	50	50	23	2.2	1050

c) Total Alkalinity

Total Alkalinity ranges from 70 mg/L to 990 mg/L, the maximum value was recorded in village *Moondli* (S5) and minimum in village *Naya Bagrana* (S4). Variation in total alkalinity of ground water samples is represented in Figure- 3 which clearly depicts that these values are more than the permissible limits of BIS, ICMR and WHO. In ground water, most of the alkalinity is caused due to carbonates and bicarbonates.

d) Total Hardness

Hardness is the property of water which prevents lather formation with soap and increases the boiling point of water. Hardness of water mainly depends upon the amount of calcium or magnesium salt or both (Singh et al. 2012). It is an important criterion for determining the usability of water for domestic, drinking and many industrial supplies (Mitharwal et al., 2009). In our findings, the value of hardness fluctuates from 30 mg/L to 980 mg/L (Figure-4), which are beyond the permissible limit as prescribed by BIS, ICMR and WHO. The minimum value was found in S32 (Village- *Ramrakhpura*) and maximum value was found in samples S10 and S12 (village- *Hardhyanpura and Ramratanpura*).

e) Calcium Hardness

Calcium Hardness varies from 10 mg/L to 480 mg/L as illustrated in Figure-5. It may be due to the presence of high amounts of calcium salts in ground water samples.

f) Magnesium Hardness

Magnesium Hardness of groundwater varies from 20 mg/L to 500 mg/L as shown in Figure-6. High values of magnesium hardness can be attributed to the large amounts of magnesium salts in ground water.

g) Chloride

Chloride contents in fresh water are largely influenced by evaporation and precipitation. Chloride ions are generally more toxic than sulphate to most of the plants and are best indicators of pollution (Rao, 2006). Chloride found high during the study ranged from 20 mg/L to 3620 mg/L (Figure-7). Minimum value was observed at samples S38, S39 and S40 and maximum value was observed at S20 in village *Ateri.* These unusual concentrations may indicate pollution by organic waste. Chloride salts in excess of 100 mg/L give salty taste to water and when combined with calcium and magnesium, may increase the corrosive activity of water (Tatawat and Singh- Chandel, 2007).

h) Nitrate

During the study Nitrate fluctuated between 9.0 to 224 mg/l (Figure-8) which is beyond the permissible limit of BIS, ICMR and WHO. In presence of high concentration of nitrate drinking water is toxic (Umavathi et al. 2007). Due to higher concentration (over 100 mg/L) of nitrate in water, infants, less than six months old, have been suffering from methamo-globinemia or blue baby disease.

i) Fluoride

Fluoride is important in human nutrition for the normal development of bones. The required level of fluoride is 1.0 to 1.5 mg/L. Higher concentration of fluoride in ground water appears to create dental, skeletal and non-skeletal fluorosis. Fluoride concentration in sampling sites ranges from 0.28 to 11.5 mg/L in ground water samples, with lowest value 0.28 mg/L (S25) in village *Mandurupura* and highest value 11.5 mg/L (S7) in village *Roopura.* As shown in Figure-9 and Table-2, most of the samples are having fluoride concentration more than the permissible limit and suffering from the acute fluoride problems.

j) Total Dissolved Solids

Total dissolved solid is an important parameter for drinking water and water to be used for other purposes beyond the prescribed limit, it imparts a peculiar taste to water and reduce its potability (Sandeep Mitharwal et al., 2009). Total dissolved solids are composed mainly of carbonates, bicarbonates, chlorides, phosphates and nitrates of Calcium, Magnesium, Sodium, Potassium, Manganese, organic matter salt and other particles (Siebert et al., 2010). In the present finding TDS value varied from 770 to 11200 mg/L (Figure-10), which is also not within the prescribed permissible limits. Maximum TDS recorded at S20 in village *Ateri* and minimum at S30 in village *Todabhata*.

Table 3 : Standards for drinking water quality

S. No.	Parameter	BIS: 1999	ICMR: 1975	WHO: 2006
1.	pH	6.5-8.5	7.0-8.5	6.5-8.5
2.	EC (μmhos/cm)	-	-	1400
3.	TA	600	600	120
4.	TH	600	600	500
5.	Cl-	1000	200	200
6.	NO_3^-	100	50	45
7.	F^-	1.5	1.5	1.5
8.	TDS	2000	1500	500

Table 4 : Statistical parameters of the different chemical constituents of ground water of the study area

S.No.	Parameter	Minimum	Maximum	Average	Standard Deviation
1.	pH	6.3	8.7	7.89	0.56
2.	EC	1100	16000	2957.72	2178.90
3.	TA	70	990	492.6	238.06
4.	TH	30	980	275	305.58
5.	Ca H	10	480	123	148.38
6.	Mg H	20	500	152	158.02
7.	Cl^-	20	3620	298.6	545.76
8.	NO_3^-	9	224	54.14	56.06
9.	F^-	0.28	11.5	3.39	3.30
10.	TDS	770	11200	2070.4	1525.23

k) Correlation of water quality parameters

In the present study, the correlation coefficients (r) among various water quality parameters have been calculated and the numerical values of correlation coefficients (r) are tabulated in Table-5.Correlation coefficient (r) between any two parameters, x & y is calculated for parameter such as water pH, electrical conductivity, total alkalinity, total hardness, calcium hardness, magnesium hardness, chloride, nitrate, fluoride and total dissolved solids of the ground water samples. The degree of line association between any two of the water quality parameters as measured by the simple correlation coefficient (r) is presented as 10 x 10 correlation matrix.

The pH has been found to show positive correlation with total alkalinity and negative correlations with electrical conductivity, total hardness, calcium hardness, magnesium hardness, chloride, nitrate, fluoride and total dissolved solids. EC has been found to show negative correlations with total alkalinity and fluoride while all other parameters are positively correlated with EC. Out of the 55 correlation coefficients, 5 correlation coefficients (r) between the EC and Cl^- (0.9651), TH and Ca H (0.9971), TH and Mg H (0.9974), Ca H and Mg H (0.9892), Cl^- and TDS (0.9651) are found to be with highly significant levels ($0.8 < r < 1.0$), and 3 correlation coefficients give the significant ($0.5 < r < 0.6$) level of r values. There is not any value of r which belongs to the moderate significant coefficient levels ($0.6 < r < 0.8$). 34 cases were calculated out positive correlation while 21 cases were calculated out negative.

Table 5 : Correlation coefficient (r) among water quality parameters

Parameter	pH	EC	TA	TH	Ca H	Mg H	Cl^-	NO_3^-	F^-	TDS
pH	1.0000									
EC	-0.4556	1.0000								
TA	0.3139	-0.2187	1.0000							
TH	-0.0404	0.3328	-0.5067	1.0000						
Ca H	-0.0246	0.3100	-0.4909	0.9971	1.0000					
Mg H	-0.0550	0.3525	-0.5189	0.9974	0.9892	1.0000				
Cl^-	-0.5632	0.9651	-0.2256	0.1908	0.1624	0.2164	1.0000			
NO_3^-	-0.4986	0.4023	-0.2502	-0.0006	-0.0333	0.0299	0.4436	1.0000		
F^-	-0.1436	-0.1058	0.1280	0.0898	0.1054	0.0747	-0.2431	-0.2555	1.0000	
TDS	-0.4556	1.0000	-0.2187	0.3328	0.3100	0.3525	0.9651	0.4023	-0.1058	1.0000

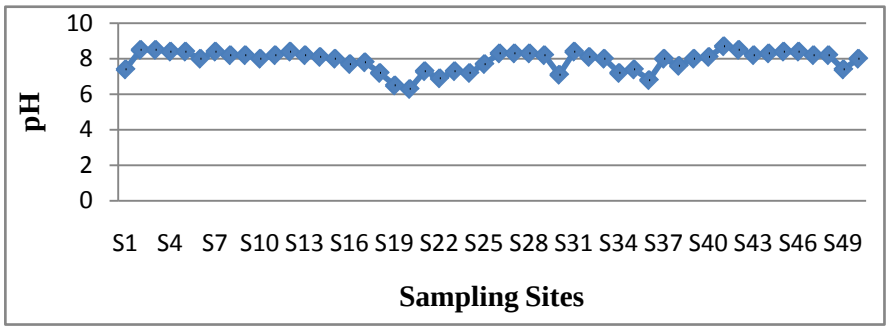

Figure 1 : Variation in pH with sampling sites of Bassi Tehsil

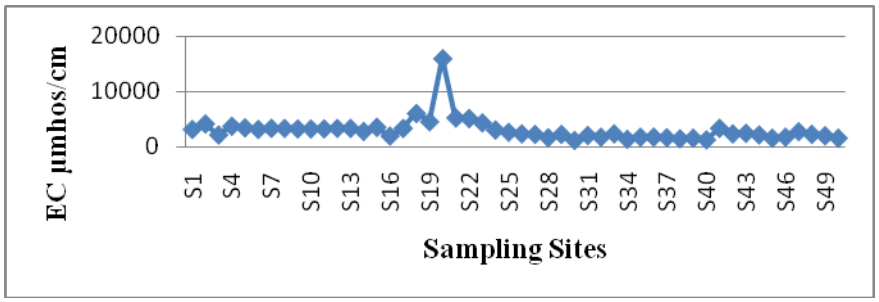

Figure 2 : Variation in EC with sampling sites of Bassi Tehsil

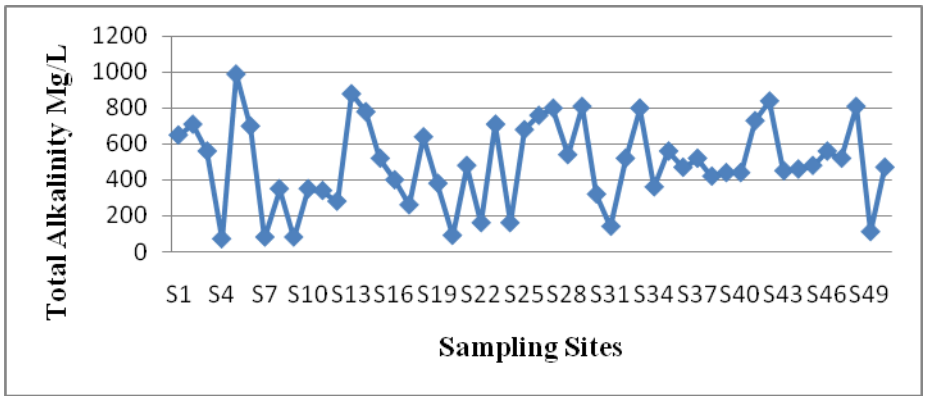

Figure 3 : Variation in Total Alkalinity (mg/L) with sampling sites of Bassi Tehsil

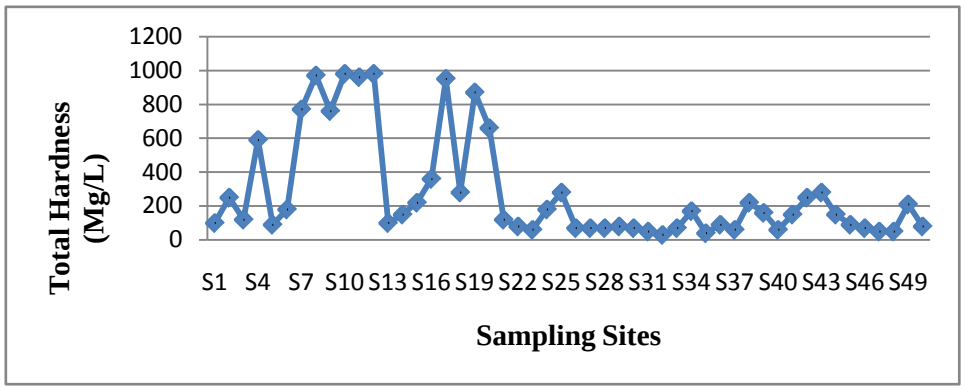

Figure 4 : Variation in Total Hardness (mg/L) with sampling sites of Bassi Tehsil

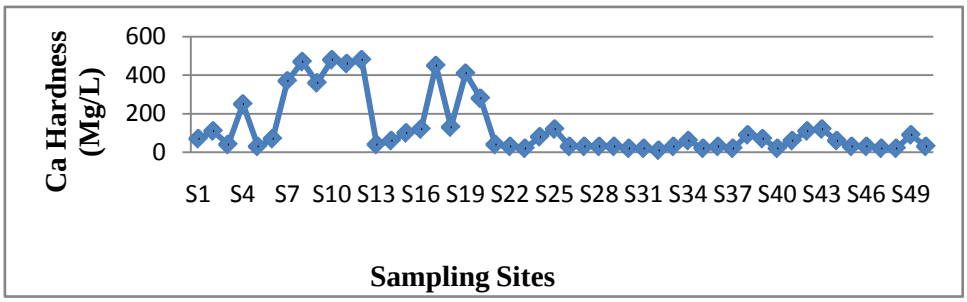

Figure 5 : Variation in Ca Hardness (mg/L) with sampling sites of Bassi Tehsil

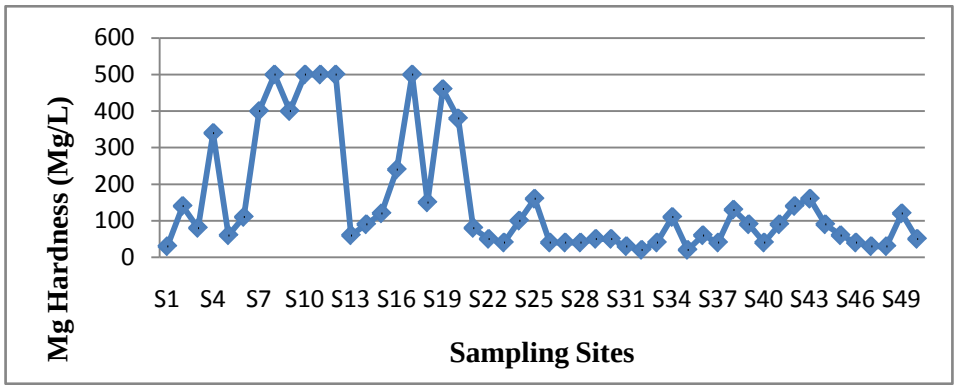

Figure 6 : Variation in Mg Hardness (mg/L) with sampling sites of Bassi Tehsil

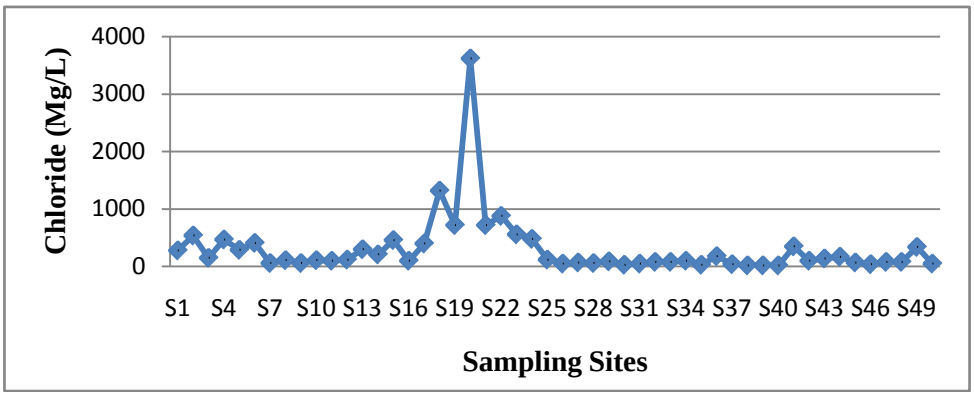

Figure 7 : Variation in Chloride (mg/L) with sampling sites of Bassi Tehsil

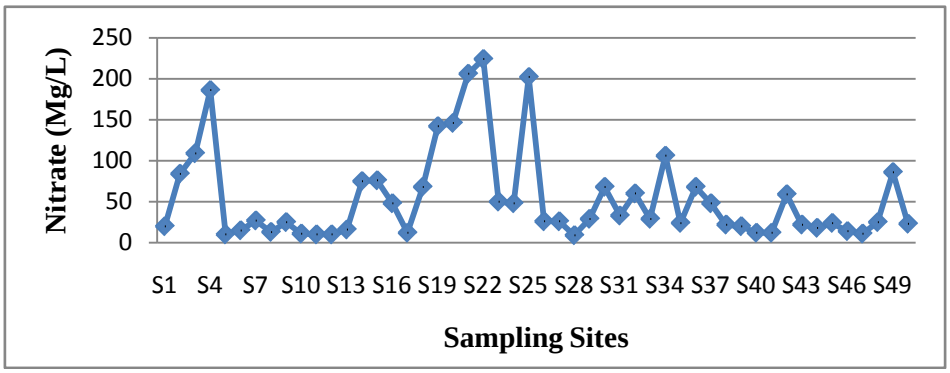

Figure 8 : Variation in Nitrate (mg/L) with sampling sites of Bassi Tehsil

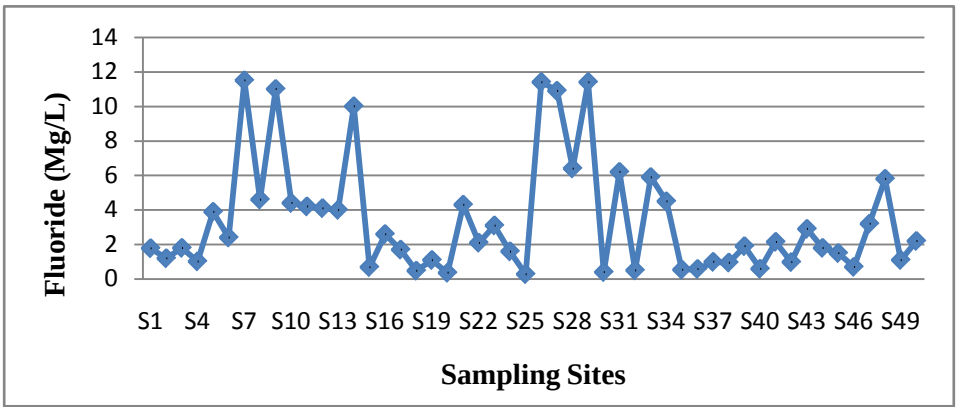

Figure 9 : Variation in Chloride (mg/L) with sampling sites of Bassi Tehsil

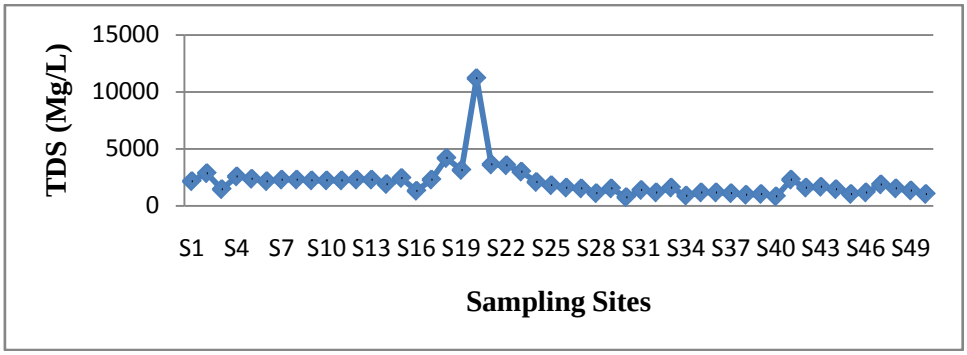

Figure 10 : Variation in TDS (mg/L) with sampling sites of Bassi Tehsil

IV. Conclusion

The analysis of ground water samples being collected from the different villages of Bassi Tehsil in Jaipur district revealed that in samples almost all water quality parameters (pH, electrical conductivity, total alkalinity, total hardness, calcium hardness, magnesium hardness, chloride, nitrate, fluoride and TDS) are beyond the permissible limit as per BIS, ICMR and WHO standards. In comparison to all other parameters, there is an acute problem of extremely high levels of Fluoride, Nitrate, Total Dissolved Solids and Chloride. As only 36% of ground water samples have fluoride content within the permissible limit (> 1.5 mg/L, WHO) and remaining 64% of villages are having very high fluoride concentrations. The favourable factor which contributes to rise of fluoride in ground water is presence of fluoride rich rock salt system.

The nitrate ion concentration of 42% of total samples was more than 45 mg/L. Some samples contai n this concentration up to 224 mg/L. The increased nitrate level in the ground water samples may be due to the consumption of large quantity of nitrogen-nous fertilizers like urea, NPK and cattle shed along with municipal wastes. 44% of ground water samples are having TDS more than 2000 mg/L (relaxed permissible limit as per BIS standards) and 36% ground water samples reported the Chloride level more than 200 mg/L.

The results of current study indicate that the drinking water, used by the people residing in villages of Bassi Tehsil, is not potable. So, the proper environment management plan must be adopted to control drinking water pollution immediately. Based on these results and analysis of water samples, it is also recommended to use water only after boiling and filtering or by Reverse Osmosis treatment for drinking purpose by the individuals to prevent adverse health effects.

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